International Journal of Innovation and Applied Studies
ISSN 2028-9324 Vol. 18 No. 1 Oct. 2016, pp. 50-57

http://www.ijias.issr-journals.org/

Relationship between physicochemical parameters of the sediments and the geological nature of the watershed of the dam Sidi Chahed (Morocco)

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ABSTRACT: In this work, we present the results of study of physicochemical parameters of sediments from the retaining Sidi Chahed dam, and the use of GIS to achieve a relationship between the geological nature of the watershed and sediments of this retaining of dam from ASTER image. The physicochemical characterization of the sediments was make in order to determine the main factors that govern the exchanges of various forms of phosphorus at the water-sediment interface, and of determining the geological nature of the land crossed by the tributary waters feeding the dam retaining.
The results obtained showed that the average values of carbonates of calcium and pH, which are respectively 36% and 8.3, are more important. The comparison of the geological map and the hydrographic network map shows that the majority of grounds crossed by the tributary waters feeding retaining of dam are the marl and limestone of Miocene, which increases the percentage of calcium carbonate in the sediments of the retaining of dam and therefore favors the dominance of fraction of phosphorus $CaCO_3$ -P (76%) in sediments.

KEYWORDS: Phosphorus, Physicochemical parameters, Sediment, Retaining of dam, GIS.

1 INTRODUCTION

The phosphorus is the most important element to consider for the evaluation of the water quality of an aquatic environment. An increase in the concentration of phosphorus favors increase plant biomass and turbidity of water, which reduces transparency. The phosphorus is considered a key nutrient responsible for the eutrophication of water bodies [1], [2], [3]. The phosphorus inputs come from discharges agricultural and urban (anthropogenic), and by the lake itself (autochthonous) at from phosphorus reserves located in the sediment [4]. This internal load constitutes often an important source of phosphorus for the Overlying water [5], [6], [7]. The Urban inputs represent a major source of chemical pollution of aquatic environments. Several studies identify municipal discharges as important contributors to nutrients, at metals and at organic substances [8], [9].

Of this fact, the equilibriums in natural aquatic environments are not stable and there is always a dynamic more or less important depending on the own nature of the ecosystem considered. The Biogeochemical variations in an aquatic environment are related mainly to changes in hydrodynamic parameters and the anthropogenic activities punctual. In retaining of Sidi Chahed dam, the physico-chemical parameters are more important (pH, $CaCO_3$, salinity) and can vary noticeably at the seasonal scale [10]. In addition, due to a strong presence of marl and limestone, the contributions in dissolved phosphorus react with calcium carbonates under the influence of a basic pH (marl and limestone) to give a precipitate as a complex [11], [12], [13]. This complex present the fraction of phosphorus bound to calcium and present 76% of the total phosphorus of sediments of the retaining of Sidi Chahed dam [14]. It is affected by the nature of waters of the retaining by mixing between the freshwaters of Wadi Mikkès and the salt waters of the Wadi Malleh. This mixture begets the important physicochemical and biological variations (conductivity, pH, nutrients, $CaCO_3$, salinity) [15], [16], [17].

The purpose of this study is determining the origins of high values of the physicochemical characteristics of sediments of retaining of Sidi Chahed dam. For this, two studies are necessary; the first is the hydrographic study that draws the network

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of tributary waters feeding retaining of dam, the second is the geological study that gives us of soil types traversed by the tributary waters of the hydrographical network.

2 MATERIALS AND METHODS

2.1 STUDY SITE

The retaining of Sidi Chahed dam is located on the Wadi Mikkès, downstream of Wadi Malleh, around 30 km to the northeast of the city of Meknes and about 30 km northwest of the city of Fez, on the road main No. 4, linking the latter to the city of Sidi Kacem (figure 1).

The construction of this dam has been destiny primarily at supply the city of Meknes with drinking water. Its capacity is 170 million m3. The watershed of Wadi Mikkès has three structural sets different [18].

- The plateau of El Hajeb - Ifrane to the south where predominant the carbonate formations whose the fracturing is strong ;
- The Saïs basin to the center, constituted by the lacustrine limestones and the tawny sands of the Pliocene as well as the Miocene marl ;
- The pre-Rif north, formed essentially by the marl of Miocene and clays Triassic (figure 2).

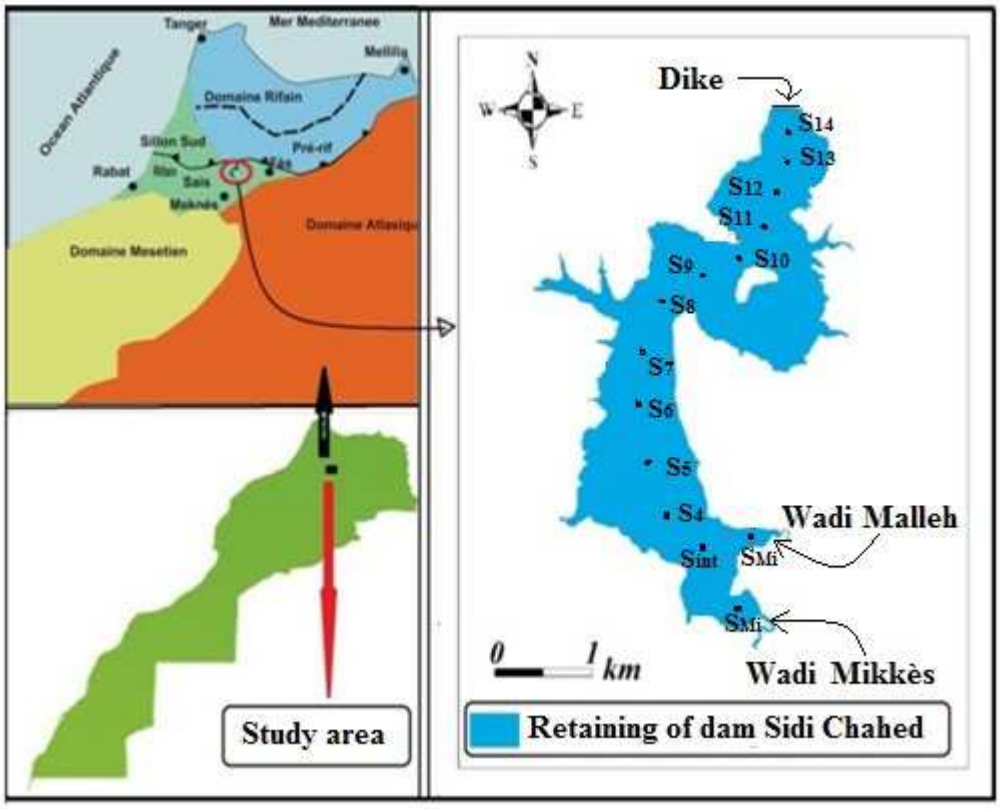

Fig. 1. Geographical location of retaining of Sidi Chahed dam and location of sampling stations

2.2 STATIONS STUDIED

Fourteen sampling stations were retained as part of this study. Including eleven (S_4 to S_{14}) were chosen spread from upstream to downstream, in order to better cover the entire area of the retaining of dam. These stations are located in the main axis of body of water. The other three were chosen almost of Wadi Malleh, Wadi Mikkès and their intersection. They are noted respectively S_{Ma}, S_{Mi} and S_{int}.

The surficial sediment samples were performed during four seasons in spring, summer, autumn 2013 and winter 2014, with a grab sampler that allowed taking the first ten centimeters of sediment. Each representative sample of a station is the

mixture of three samples from points spaced few meters. The samples are kept in plastic bags in a portable cooler at 4 ° C during transportation to the laboratory where they are processed within 24 hours. All sediments were sifted by wet process. The fraction smaller than 200 microns was retained for analysis, after drying and grinding soft to the mortar to homogenize the sample.

The physicochemical parameters of sediments were carried out in the laboratory using the methods described below:

- The content water of sediment was determined by differential weighing after drying of a known mass accurately of wet sediment (<2 mm) at 105 °C to constant weight. This parameter is determined dice the arrival of the sample to the laboratory to minimize evaporation risks [19], [20].
- The determination of the carbonate content was performed using the calcimeter Bernard. This Calcimeter allows measuring the percentage of $CaCO_3$ content in sediment.
- The content of organic matter (OM) of sediment was determined by differential weighing, after calcination of 1 g of dry and milled sediment, in a muffle furnace at 550 °C for two hours [20].
- The pH is measured using a pH meter according to the method described by Rofes [19].
- The total phosphorus is dosed like orthophosphate, after mineralization of the sediment with $K_2S_20_8$ in acid medium [21]. This mineralization is effected at 120 °C at autoclave for one hour. It allows us the solubilization of total phosphorus [22].
- The conductivity was measured using the AFNOR (1995) [23] which is based on extracting salts of a sample, soluble in water, in well-defined conditions and within a weight ratio of dry sediment / water equal to 1/5.

3 RESULTS AND DISCUSSION

3.1 PHYSICOCHEMICAL PARAMETERS

On Table (1) we have ported means and standard deviations calculated, related to values of four seasons for each parameter studied. Note that the standard deviation was calculated to determine the importance of the seasonal variation of each parameter.

Table 1. Means and standard deviation (σ) of physico-chemical parameters of sediments of the retaining of Sidi Chahed dam.

Station	Water content (%)		OM (%)		pH		Cond (µs/cm)		$CaCO_3$ (%)		P (µg/g)	
	Mean	σ	Mean	σ	Mean	σ	Mean	Mean	Mean	σ	Mean	σ
SMa	69.25	2.63	8.84	2.86	8.25	0.91	830.00	116.69	34.39	4.17	554.07	40.48
SMi	71.25	1.89	7.47	2.04	8.28	0.80	572.25	197.73	34.71	2.11	593.25	39.52
Sint	70.40	1.92	9.57	2.96	8.33	0.81	837.50	229.44	34.29	4.60	564.98	44.26
S4	70.67	3.10	9.26	1.27	8.23	0.83	791.50	135.48	35.61	4.97	537.70	57.71
S5	70.67	1.05	9.69	3.76	8.29	0.97	729.00	125.45	36.84	3.49	579.86	15.23
S6	68.85	1.70	9.28	3.07	8.38	0.88	855.25	261.80	35.51	3.89	578.37	51.60
S7	72.19	1.47	10.39	3.42	8.43	0.84	618.75	196.91	35.82	4.52	578.87	30.19
S8	68.58	2.42	8.62	2.79	8.30	0.96	770.25	256.57	37.60	3.65	503.47	29.67
S9	72.75	2.22	10.32	2.98	8.31	0.82	1003.75	184.72	36.36	1.66	616.07	29.36
S10	74.40	2.53	9.07	2.03	8.18	0.78	730.00	163.71	37.32	2.25	607.14	45.07
S11	69.88	1.75	9.27	1.80	8.35	0.89	727.50	321.49	38.00	6.37	614.58	48.88
S12	68.35	1.54	8.39	1.40	8.25	0.89	812.50	430.61	39.10	2.28	618.06	49.79
S13	69.66	1.55	8.87	3.51	8.22	0.98	850.50	510.99	36.82	2.05	584.82	38.83
S14	72.50	2.51	9.87	2.75	8.20	0.84	886.00	202.51	34.64	3.25	603.17	67.13

The total phosphorus content of the sediment varies between 504 and 618 mg (P)/g of sediment with an average of 581 mg (P)/g of sediment. This could be the result of sedimentation of particles rich in phosphorus.

The values enough important of carbonates vary between 34% and 39% are the answer to the predominance of marl lands of Miocene very sensitive to water erosion and landslides mainly in the presence of a rugged mountainous terrain.

According to Abdallaoui 2013 [24], the carbonates have a relatively important role in the precipitation of heavy metals and also in the retention of phosphorus from sediments.

The pH values recorded in this study are high and clearly reflect the influence of Wadi Malleh (salted watercourse) whose waters flow into the retaining of Sidi Chahed dam. This basic character reflects also the sedimentary nature dominated by the nature of the land crossed.

The average value of the conductivity of the sediments is on the order of 787 µS/cm. This increase in conductivity returning to the very important quantity of salt minerals that comes from two formations: Triassic formation and salt formation in the form of rock salt (NaCl) and gypsum ($CaSO_4$).

The organic load in sediments studied has high values. These contents enough important allows us to say that enrichment of bottom sediments of the retaining of Sidi Chahed dam by organic matter is probably due:

- Either by degradation of dead cells of the fauna and of the flora within the retaining of dam;
- Either to leaching of soil surrounding this water body;
- Either by discharges to organic character ;
- Either by the sum of two.

The measurements of water content which provide information on the particle granulometry and the organic matter content were performed on all samples. The results of these measurements have showed that the sediments of the retaining of Sidi Chahed dam have the contents on average 71%. This translated a fluidity relatively important.

The values of the standard deviation of the parameters studied except those relating to water contents are considered relatively enough important to the averages of the values in these parameters. They indicate the existence of variations seasonal significant in physicochemical parameters studied, with the exception of water contents. These variations may be related to precipitation (flood season) which promotes the water dilution and that causes a decreases of the conductivity and pH of the water column and as the result those of sediment. The decrease in pH of the water column in turn contributes to reducing calcium carbonates and phosphorus bound to calcium in sediments [25], [26]**.** Similarly the increase in temperature during dry seasons facilitates the degradation of organic matter by bacterially process and promotes the release of phosphorus bound to the iron [27] that is the decrease in the amount of phosphorus bound to the sediments.

3.2 GEOLOGICAL STUDY. HYDROGRAPHIC

In this study, we are interested at two types of maps: geological map (Figure 2) and hydrographical network map (Figure 3) which aims of determine and interpret the types of soil transported by flowing waters to retaining of Sidi Chahed dam.

The figure 2 shows that:

- The area covering the retaining of dam is predominated by marl Miocene land.
- The waters of the sub-watershed of Wadi Maleh flow on red clay of Trias.
- The waters of the Wadi Mikkès through lacustrine limestones of Saïs.

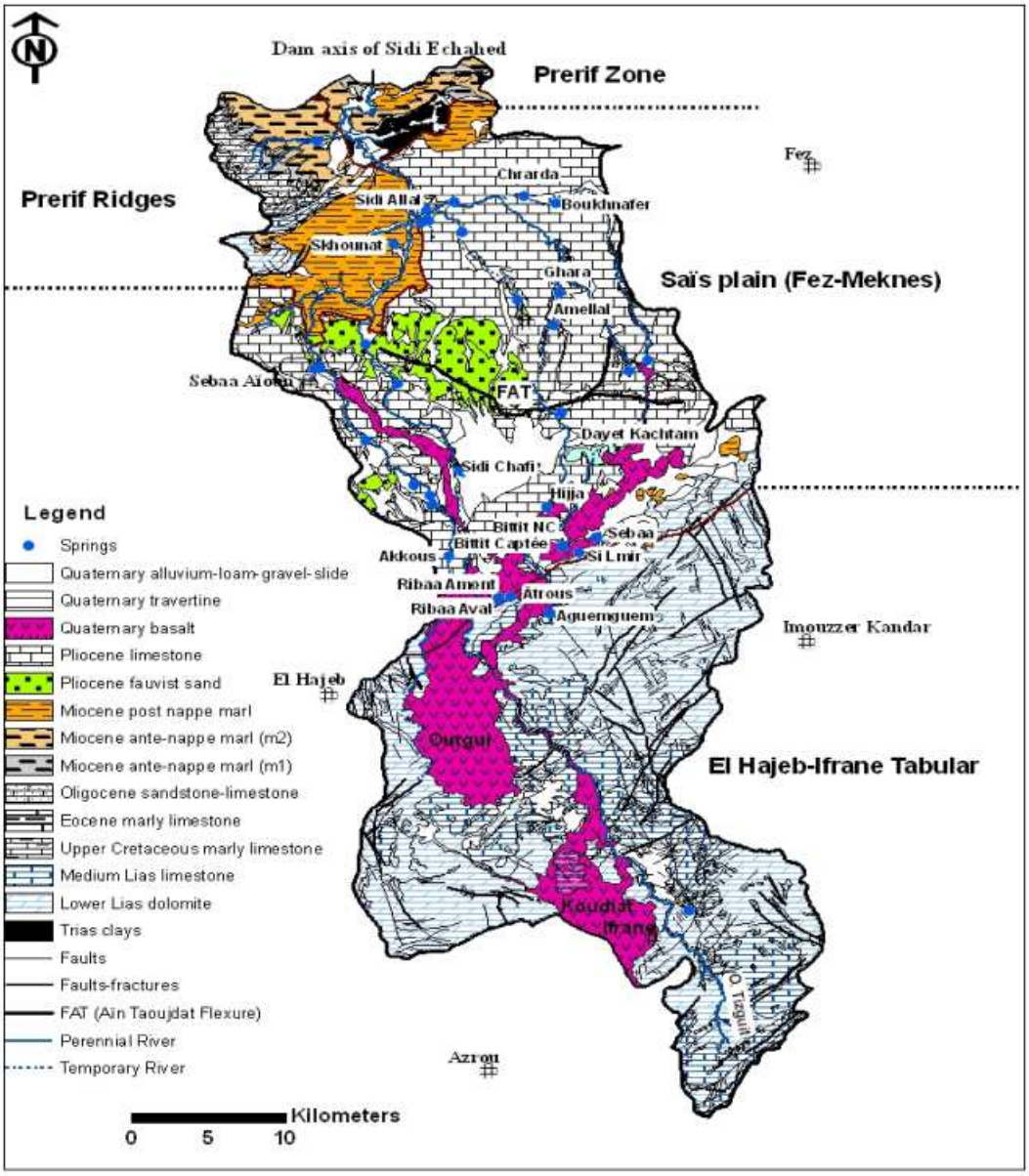

Fig. 2. Geological map of the watershed of Wadi Mikkès [28]

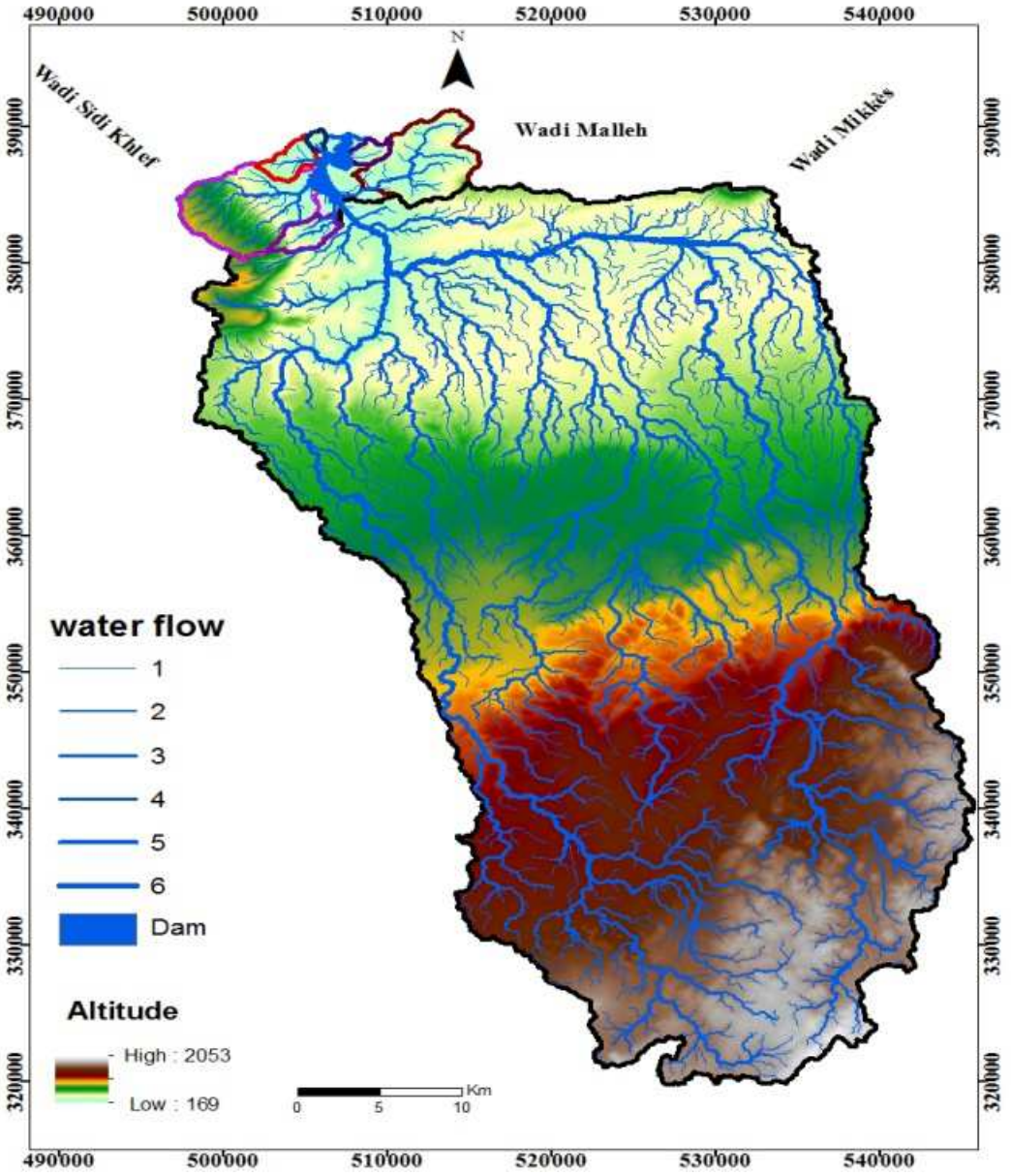

Fig. 3. Map of the hydrographical network of the watershed of Wadi Mikkès

The map of hydrographical network shows the subwatersheds that feed the dam retaining.

The superposition of the hydrographic map network with the geological map has allowed us to have the types of soil transported to the dam used by the sub-watersheds.

In the eastern part, the red clays of the Triassic the retaining of dam by the impact salts inputs are transported by the Wadi Malleh. Towards the South the lacustrine limestone of Saïs are transported by the Wadi Mikkès. The Marls and Miocene limestone is transported by the rest of the hydrographic network.

After the foregoing, we can see that the calcareous sediments nature is the origin of the geological nature of the watershed of Wadi Mikkès and that the carbonates and the pH of the waters of the retaining of dam are responsible for the precipitation of phosphorus bound to calcium. This is in agreement with the results obtained by many authors [11], [12], [13].

4 CONCLUSION

The results that we have obtained in this study allowed us to get the interesting information on how phosphorus exists within the sediments of the retaining of Sidi Chahed dam.

The marl and the limestone of Miocene surround almost the entire area surrounding the retaining of dam, which are the base of calcium carbonates. This information allowed us to conclude that the sediments of the retaining of Sidi Chahed dam which are characterized by high content of $CaCO_3$ is in accordance with the geological nature of the terrain.

Similarly, the waters of watershed of Wadi Malleh contribute to the alkalinity of waters of retaining of dam (increase of pH). Which promotes the precipitation of the fraction of phosphorus bound to calcium the fact that the carbonates and the pH are additional factors which favors the predominance of the inorganic phosphorus form.

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